Agriculture and Agri-Food Canada
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Water Quality Matters

ALUMINUM AND HEALTH

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WHAT IS ALUMINUM?

Aluminum is the most abundant metal in the earth's crust. It is naturally present in soil, water and air. Alloyed with other elements, aluminum is commonly used in the construction of siding, aircrafts, and lightweight utensils because of its strength and light weight. Dissolving aluminum compounds with sulphuric acid will produce aluminum sulphate, otherwise known as alum. Alum is used in a wide range of water treatment applications ranging from large, municipal water plants to on-farm dugout coagulation practices. (For more information about coagulation refer to the **Water Quality Matters** publication "Dugout Coagulation".

There are both advantages and disadvantages to using alum for water treatment. Although aluminum in drinking water has been suggested as a cause of some neurological diseases, scientific research has not been able to support this. In order to understand the issues and risks, the characteristics of aluminum need to be examined.

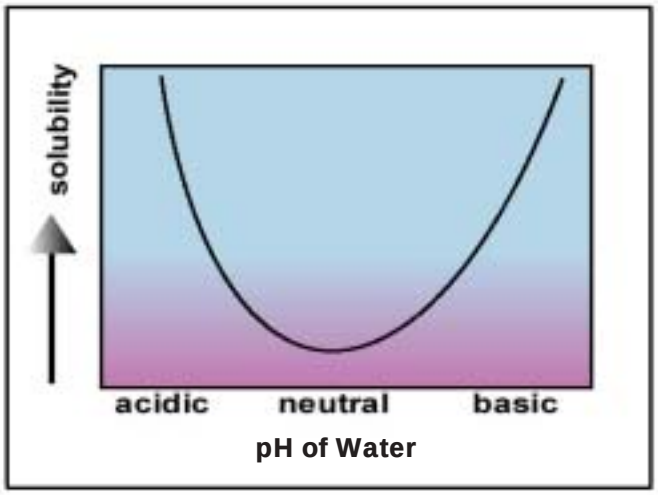
WHAT HAPPENS TO ALUMINUM IN WATER?

Aluminum is a reactive metal, and usually occurs bound to other elements or compounds. The ability of aluminum compounds to dissolve in water is affected by the condition of the water. The pH of the water is the main factor in determining how well aluminum compounds will dissolve. See Figure 1. Unless conditions are very acidic or basic, little aluminum will remain in solution. Rather, it will precipitate out of the water column as a white or off-white floc. The same conditions that affect the physical characteristics of aluminum compounds also affect the size and appearance of the floc.

Alum coagulation greatly improves the clarity of water which allows disinfectants to work much more effectively

When aluminum precipitates out of water, it takes other substances with it. This is known as coagulation. If conditions are good, the coagulated material (floc) forms large, heavy particles which quickly settle out of the water column. However, some residual aluminum is always left in solution.

Figure 1 - Solubility of aluminum relative to pH



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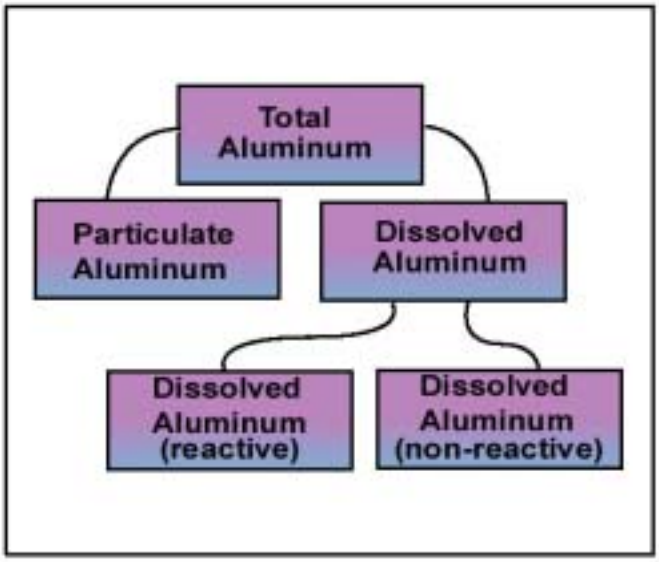
Aluminum reactions in water are complex, as reactions differ depending upon pH levels. Aluminum levels are usually measured as total aluminum, which is the sum of all dissolved and particulate aluminum forms. See Figure 2. Although aluminum exists naturally in water, treating water with additional aluminum tends to change the form in which it occurs.

Figure 2 - Aluminum levels



In raw water, much of the total aluminum is in the particulate form. In treated water, the overall amount of aluminum can be lower, but a greater proportion of what remains is in the dissolved form. Dissolved aluminum occurs as compounds that range from being fairly reactive (bound to inorganic complexes) to fairly unreactive (bound to organic complexes). It is the reactive components that have raised some concerns over the safety of drinking water.

WHY IS ALUMINUM USED IN DRINKING WATER SYSTEMS?

Good water treatment is a multi-stage process. In order for components of a treatment system to work well, the water must be brought to certain quality levels. In most treatment systems, one of the final stages involves disinfection. For effective disinfection, water must already be of a high quality. This allows the disinfectant to reach its targets, instead of letting contaminants 'hide' in turbid or silty water.

Aluminum coagulants remove sediment, nutrients, microbes and dissolved organic carbon, improving greatly the quality of water. Good coagulation clarifies water to the point where disinfection is easier, better and safer.

Common coagulants in water treatment include salts or polymers of both aluminum and iron. The advantage of aluminum compounds is that they settle out a wide variety of unwanted material without the taste and staining problems associated with iron.

WHAT ARE THE COMMON SOURCES OF ALUMINUM?

The American Waste Water Association (AWWA) has estimated that drinking water (including treated water) provides about 5% of overall aluminum in human diets. Most aluminum consumed by humans comes from food and beverages other than plain water. This list includes:

- inhalation, especially in certain industrial settings
- soil clinging to unwashed fruits and vegetables
- processed foods
- baked goods (aluminum is used to stabilize baking powder and flour)
- brewed drinks
- over-the-counter antacid preparations
- anti-perspirants
- cooking utensils, containers and foil

(Journal of the AWWA, May 1995).

WHAT ARE THE HEALTH RISKS?

Unlike iron, aluminum is not known to have any direct, positive health effects on humans. Adverse effects of aluminum are currently known to be far more chronic (occurring over the long term) than acute (occurring in the short term). Aluminum has been shown to be a neurotoxic compound if it is allowed to enter the bloodstream. Long-term exposure of patients to dialysis water high in aluminum may cause encephalopathy (defect of the brain) and/or bone mineralization disorders.

Aluminum has also been suggested as a cause of Alzheimers disease, Lou Gehrig's disease and other forms of senile dementia. It is still unclear if aluminum leads to these diseases or if it is that the diseases cause brain tissues to retain aluminum secondarily.

It has not been shown clearly that normal eating or drinking in a healthy individual will cause elevated aluminum levels in the blood. This is true even if all cooking is done with aluminum pots and utensils.

Aluminum is likely to be in a dissolved form in the stomach since aluminum compounds remain in solution at extremely low pH levels. Uptake in the stomach might be a risk if the stomach lining has been damaged from stress or overuse of ethanol or aspirin. However, almost all absorption normally occurs in the intestines, which have a much higher pH. At intestinal pH levels, most aluminum will precipitate to a solid and be excreted.

Concern has been raised about the ability of some dissolved forms of aluminum to be absorbed by the small intestine (bioavailability). This may be of importance to the elderly and people with weakened immune systems. In a literature review completed by Health Canada, some researchers suggest that the uptake of aluminum can be enhanced by citric and other related acids. However, uptake may be limited by the presence of other things in the water that aluminum would rather bind to, like phosphates. More research is needed on this aspect.

OTHER OPTIONS

Iron salts or polymers are also suitable coagulation chemicals. They are not as widely used as aluminum compounds. This is because any residual iron in the water tends to precipitate throughout the system, resulting in staining and potential line blockage. Iron in water can also lead to blooms of slime-forming iron bacteria. These bacteria are not a health concern, but they are unsightly and heavy growths can also block water lines.

If iron compounds are used as coagulants, finished water is often passed through an iron filtering process before distribution. This is done to minimize the negative impacts of taste and staining for customers. However, these effects cannot always be completely eliminated.

For personal, in-house systems there are a variety of options for primary treatment that do not involve aluminum. For more information see the **Water Quality Matters** publications "Evaluation of Treatment Systems", "Approaches to Water Treatment" and "Biological Treatment of Surface Water". These include slow sand filters and granular activated carbon (GAC). The primary disadvantage to many in-house systems is the need for continued, regular maintenance from the homeowner. If aluminum is used as an initial clarifier, reverse osmosis systems will effectively remove most dissolved aluminum from finished water.

THE BIG PICTURE

At present, there are no guideline recommendations for maximum aluminum concentrations in finished water. The health effects of aluminum are still under investigation. It is certain that aluminum has no direct, positive effects on humans. However, there are certainly very positive, indirect effects such as the improved water clarity after alum coagulation.

The long term risks of aluminum use are as of yet uncertain. The short term risks from improper disinfection of poorly clarified water mean increased risk of exposure to disease-causing microbes. It will be up to individual water users to balance the possible risk of using aluminum with the benefits it provides while further research continues.

For further information on rural Prairie water quality and treatment technology:

- read the other publications in PFRA's **Water Quality Matters** series;
- visit the PFRA Web site at www.agr.gc.ca/pfra;
- get a copy of "Rural Prairie Water Quality: Searching for Solutions for On-Farm Users", available from PFRA;
- read Prairie Water News, available from PFRA or on the Internet at www.quantumlynx.com/water; or
- **contact your local Prairie Farm Rehabilitation Administration Office** (PFRA is a branch of Agriculture and Agri-Food Canada).

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